

CLAIMS

We claim:

1 1. A circuit comprising:
2 a diode string coupled to a supply voltage line; and
3 a transistor coupled to the diode string and to a reference
4 voltage line, wherein the diode string and the transistor are
5 implemented in a cascode configuration and provide electrostatic
6 discharge protection.

1 2. The circuit of Claim 1, wherein the diode string
2 comprises:
3 at least a first diode coupled between the supply voltage
4 line and the reference voltage line and adapted to provide
5 electrostatic discharge protection having a first polarity; and
6 at least a second diode coupled to the supply voltage line
7 and adapted to provide electrostatic discharge protection having
8 a second polarity.

1 3. The circuit of Claim 2, wherein the second diode has
2 at least a first terminal coupled to a drain terminal of the
3 transistor.

1 4. The circuit of Claim 1, wherein the transistor and the
2 diode string have different diffusion regions.

1 5. The circuit of Claim 1, further comprising a resistor
2 coupled between a gate terminal of the transistor and the
3 reference voltage line, wherein the circuit provides
4 electrostatic discharge protection for a power rail of an
5 integrated circuit incorporating the circuit.

1 6. The circuit of Claim 1, further comprising a pull-up
2 circuit coupled between the supply voltage line and the diode
3 string, wherein the pull-up circuit and the diode string are
4 coupled to an input pad and/or an output pad, the transistor is
5 adapted to receive a control signal at its gate terminal, and
6 the circuit provides electrostatic discharge protection for an
7 interface of an integrated circuit incorporating the circuit.

1 7. The circuit of Claim 6, wherein the circuit is adapted
2 to operate as a driver.

1 8. The circuit of Claim 1, wherein the circuit is adapted
2 to operate in a mixed voltage environment.

1 9. The circuit of Claim 1, wherein one or more diodes
2 within the diode string may be implemented as bipolar
3 transistors.

1 10. A programmable logic device comprising:
2 at least a first diode coupled between a supply voltage
3 line and a reference voltage line and adapted to protect from
4 electrostatic discharge of a first polarity;
5 at least a second diode coupled between the supply voltage
6 line and the reference voltage line and adapted to protect from
7 electrostatic discharge of a second polarity; and
8 a transistor coupled between the at least first diode and
9 the reference voltage line.

1 11. The programmable logic device of Claim 10, wherein the
2 transistor and the at least first diode are implemented in a
3 cascode configuration and adapted to operate in a mixed voltage
4 environment.

1 12. The programmable logic device of Claim 11, wherein the
2 transistor and the at least first diode have different diffusion
3 regions.

1 13. The programmable logic device of Claim 10, further
2 comprising a resistor coupled between a gate terminal of the
3 transistor and the reference voltage line, wherein the at least
4 first diode, the at least second diode, the transistor, and the
5 resistor provide electrostatic discharge protection for a power
6 rail of the programmable logic device.

1 14. The programmable logic device of Claim 10, wherein the
2 at least second diode has a first terminal coupled to a drain
3 terminal of the transistor.

1 15. The programmable logic device of Claim 10, further
2 comprising a pull-up circuit coupled between the supply voltage
3 line and the at least first diode, wherein the pull-up circuit
4 and the at least first diode are coupled to a pad, the
5 transistor is adapted to receive a control signal at its gate
6 terminal, and the at least first diode, the at least second
7 diode, and the transistor provide electrostatic discharge
8 protection for an interface of the programmable logic device.

1 16. The programmable logic device of Claim 10, wherein the
2 at least first diode and/or the at least second diode comprise a
3 bipolar transistor.

1 17. A method of providing electrostatic discharge
2 protection, the method comprising:

3 providing at least a first diode coupled to a supply
4 voltage rail to protect from electrostatic discharge of a first
5 polarity;

6 providing a transistor coupled between the at least first
7 diode and a reference voltage rail; and

8 providing at least a second diode coupled to the supply
9 voltage rail and to the reference voltage rail or between the at
10 least first diode and the transistor to protect from
11 electrostatic discharge of a second polarity, wherein the at

12 least first diode and the transistor are implemented in a
13 cascode configuration.

1 18. The method of Claim 17, wherein the at least first
2 diode and the transistor are implemented having different
3 diffusions.

1 19. The method of Claim 17, further comprising operating
2 the at least first diode, the at least second diode, and the
3 transistor as a clamp circuit.

1 20. The method of Claim 17, further comprising operating
2 the at least first diode, the at least second diode, and the
3 transistor as a driver to transfer data via a pad.

1 21. The method of Claim 17, further comprising providing a
2 pull-up circuit between the supply voltage rail and the at least
3 first diode.

1 22. The method of Claim 17, wherein the at least first
2 diode and/or the at least second diode comprise a bipolar
3 transistor.